R E P O R T R E S U M E S

ED 011 236 SE 000 047

THE RELATIONSHIP OF THREE FACTORS IN PRINTED MATERIALS TO STUDENT ACHIEVEMENT.

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PUB DATE MAR 66

EDRS PRICE MF-$0.09 HC-$0.52 13P.

DESCRIPTORS- *ASTRONOMY, *ACADEMIC ACHIEVEMENT, *CURRICULUM, *ELEMENTARY SCHOOL SCIENCE, *STUDENT ATTITUDES, EVALUATION, GRADE 6, INSTRUCTIONAL MATERIALS, ELEMENTARY SCHOOL SCIENCE PROJECT, FLORIDA

THE EFFECT OF PLANNED DIFFERENCES IN TEXTUAL MATERIALS ON ELEMENTARY STUDENTS' SCIENCE ACHIEVEMENT AND ATTITUDES WAS INVESTIGATED. A CHAPTER FROM A RECENT SCIENCE TEXT WAS REWRITTEN IN SIX DIFFERENT FORMS WHICH EMPHASIZED OR DEEMPHASIZED QUESTIONS, ACTIVITIES, OR INCONGRUITIES INCLUDED IN THE ORIGINAL FORM. THE MATERIALS WERE RANDOMLY ASSIGNED TO 35 SIXTH-GRADE CLASSES IN 13 SCHOOLS. STUDENTS WERE PRETESTED AND POST-TESTED FOR ACHIEVEMENT. THE POST-TEST INCLUDED QUESTIONS RELATED TO STUDENT ATTITUDES TOWARD ASTRONOMY AND THE INSTRUCTIONAL MATERIALS. DIFFERENCES IN ACHIEVEMENT BETWEEN TREATMENT GROUPS WERE DETERMINED THROUGH ANALYSIS OF COVARIANCE. ALL SUBGROUPS ANALYZED, EXCEPT FEMALES WITH MENTAL AGES IN THE UPPER QUARTILE OF THE SAMPLE, SHOWED SIGNIFICANT GAINS IN ACHIEVEMENT. ACTIVITY PRODUCED THE HIGHEST ACHIEVEMENT SCORES FOR THE MAJORITY OF THE STUDENTS. STUDENTS WITH MENTAL AGES IN THE UPPER QUARTILE, HOWEVER, SCORED HIGHER WHEN ACTIVITY WAS DEEMPHASIZED. A DEFINITE RELATIONSHIP WAS IDENTIFIED BETWEEN THE LEARNING MATERIALS WITH THE GREATEST NUMBER OF ACTIVITIES AND FAVORABLE STUDENT ATTITUDES. THIS ARTICLE IS PUBLISHED IN THE "JOURNAL OF RESEARCH IN SCIENCE TEACHING," VOLUME 4, ISSUE 1, 1966. (AG)

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JOURNAL OF RESEARCH IN SCIENCE TEACHING

Volume 4 —— Issue 1 —— 1966

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Published under the auspices of
NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING *and*
ASSOCIATION FOR THE EDUCATION OF TEACHERS IN SCIENCE *by*
John Wiley & Sons, Inc., New York • London • Sydney

SE 000 017

JOURNAL OF RESEARCH IN SCIENCE TEACHING

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Published quarterly (March, June, September, December) by John Wiley & Sons, Inc.

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Publication Office at 20th and Northampton Streets, Easton, Pennsylvania 18043. Executive, Editorial, and Circulation Offices at 605 Third Avenue, New York, New York 10016. Application for Second-class postage pending at Easton, Pa. Subscription price, $10.00 per volume. Single issue price, $3.00. Foreign postage, $0.50 per volume. Manuscripts should be submitted in duplicate to Prof. J. Stanley Marshall, Department of Science Education, The Florida State University, Tallahassee, Florida 32306.

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JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 4, PP. 28–36 (1966)

In the design of curriculum materials, we should strive for a systematic method in which certain critical factors related to student achievement can be consciously incorporated, according to the author. The teacher might then assume the role of diagnostician.

The Relationship of Three Factors in Printed Materials to Student Achievement

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The curriculum designer, today, is confronted with unique tasks with respect to selection of subject matter. He is asked to keep abreast of changing data and theories within the disciplines and also to identify what content is to be incorporated into the existing program. To accomplish these tasks, he must be knowledgeable about each discipline; but to be constantly conversant with any one discipline, requires continuous study. Bingham[1] has pointed out that nearly everything known now in the sciences was unknown when most adults were in school.

As an educator, the designer is faced also with new evidence in psychology which points to a revised theory of learning—a theory which encourages the introduction of content to students at an earlier age than heretofore thought feasible and that accents the desirability of doing so. Fraser[2] sees the educator, in an attempt to meet the challenge, slowly moving from the learner-centered curriculum toward the discipline-centered curriculum. Optimally, the teacher will soon be helping his students develop newly identified concepts of the disciplines through a process grounded in the emerging psychology.

Scholars, scientists, and teachers are becoming increasingly aware of the shortcomings of continuing our present practices in curriculum revision. These efforts usually take the form of periodically depositing newly found data on the existing foundation. Partly from this concern a theory has developed: under each discipline lies a structure which supports its body of accumulated knowledge. It is the understanding of this structure which lends intellectual power to the student, not the nonsequential fragments currently in the curriculum. Bruner,[3] in summarizing the thoughts of leaders from a number of disciplines, stated:

> Designing curricula in a way that reflects the basic structure of a field of knowledge requires the most fundamental understanding of that field. It is a task that cannot be carried out without the active participation of the ablest scholars and scientists.

The problem of curriculum revision and implementation becomes acute and complex. In turning to the structure of the discipline, there is the probability that much of our present curriculum, often considered trivial, will be replaced. Basic concepts known to and identified by the leaders in the disciplines will supplant existing curriculum content. It would not be unreasonable to state that most of these concepts are either foreign to, or at best only vaguely recognized by, the present classroom teacher. It is beyond reasonable expectation that the general practitioner in the classroom will be at ease in this new arena.

Scholars and scientists, although specialists in their realms, would have a difficult time, indeed, communicating the basic concepts which they have identified to elemen-

tary school children. This task has been left, in most of the current curriculum revision projects, in the hands of the educator. He, in turn, through production of instructional materials, must interpret to children. In many instances, the teacher is ill equipped to teach these specialized areas and could conceivably do a great injustice to both the student and the discipline. It would appear that if this trend is to continue, the learning materials of the future must be capable, so to speak, of carrying their own weight.

It is unrealistic to believe that all elementary school teachers can be trained to teach any discipline at any depth or that it would even be possible to train a substantial number of them to be highly competent in any one discipline. It is more realistic perhaps to think that if a systematic method of preparation of materials could be found, one in which critical factors related to achievement could be consciously incorporated, then the teacher could assume the role of diagnostician. It would be his task to assess the conceptual level of the child and match this judgment with the myriad of possible areas to be explored. It is toward the problem of design of curriculum materials that this study was directed.

Related Research

To date, little research has been produced to give direction to the problem. Lumsdaine[4] reports that few studies have been done

> . . . in which the format or content of the printed textual material has been experimentally manipulated in a situation involving supervised reading for a fixed interval or a similarly structured situation. A further potential exception might be envisaged in a large-scale field experiment in which the experimental factor is availability of text or reference materials in two or more clearly differentiated alternative forms. Such a study would require a considerable sampling of classes or schools, and teachers. It would pose the question: Does placing one kind of text in the hands of teachers or students result (despite probable wide variation in the conditions of its use) in differences in achievement? No such studies on conventional textbooks are known to the author . . .

Statement of the Problem

Through concern with the usual trial and error method of material preparation, this study was an attempt to investigate differences in student achievement and attitude formation due to planned differences in textual materials. These differences were determined and controlled through the manipulation of three factors: (*1*) number of questions, (*2*) number of activities, and (*3*) number of incongruities. These three factors were selected because of their apparent importance in the learning process. It is readily conceded that these factors are not all inclusive and that two or more in varying combinations may provide variances in the results. However, it is hoped that through the act of identifying their role in isolation, this study may provide possible direction or avenues for further study for those concerned with preparation of instructional materials.

Content Selection

The initial effort in this study was to locate content which would meet three criteria: (*1*) It must either contain or lend itself to inclusion of all three factors—questions, activities, and incongruities—in varying combinations; (*2*) It must lend itself to a variety of reorganizations, which would be necessary if the factors were to be rigorously manipulated; (*3*) It must be unfamiliar to the students but must not demand a higher degree of competence than could be expected of students at the selected grade level.

In view of these criteria, content was selected from Chapter Four, "Charting on the Earth," from the text, *Charting the Universe*. The text is a publication of the University of Illinois Elementary-School Science Project. It was the result of a team of astronomers and educators jointly attempting to interpret to students what content the former group felt to be basic to astronomy. As such, the content is radically different from that which students are ordinarily taught in the traditional astronomy program.

The chapter did demand certain prior knowledge of angles, triangles, circles, and scale drawings. Because the purpose of the treatments was not to teach these specific skills, and it was not feasible or desirable to request that students in the project be taught these skills prior to the treatments, it was decided that the study could most effectively be done with sixth grade students. Most boys and girls of this grade level are in adequate possession of the forementioned skills as was established through an examination of mathematics and social studies texts designed for fifth and sixth grade students.

A survey of the chapter revealed thirteen questions, fourteen activities and what can be considered as three incongruities. Thus, all three factors were in evidence and all appeared to be manipulative.

Test Development

To ensure a comprehensive test coverage, "Guidelines of Content for Chapter Four" was developed by the investigator using seven categories as identified by Bloom.[5] These categories were: (*1*) Principles and Generalizations; (*2*) Terminology; (*3*) Specific Facts; (*4*) Methodology; (*5*) Translation; (*6*) Extrapolation; and (*7*) Application. Both Chapters Four of the text and of the Teachers' Manual were thoroughly scanned for learnings which would fall into each category.

Once the guideline was complete, the investigator constructed a number of multiple choice questions for entries within each category with some assurance that the content of the chapter was being sampled. The result was a test of ninety-three items.

Interviews were held with a sixth grade student who had studied the material the previous year to get some idea of how such a student would interpret the questions. Following this, the test was read by a fifth grade student reading on a fifth grade level, a level not uncommon to many of the prospective subjects to get some idea of the difficulties a student reading below sixth grade level would encounter. After these interviews, where necessary, test items were rewritten to eliminate any confusing sentence structure, vocabulary, or other stumbling blocks.

The test was submitted to forty sixth grade students who had completed a study of "Charting on the Earth" within the week. An item analysis was conducted and for each item the difficulty level and the internal validity were established; the former through a formula given by Lindquist[6] and the latter through use of an abridged table of Flanagan's table of normalized biserial coefficients, as described by Garrett and Woodworth.[7]

Fifty-five items were identified as being acceptable for Trial Test II. The items were again compared with the "Guideline of Content Coverage for Chapter Four" to establish that the content was adequately sampled. This final test was administered to sixty-two sixth grade subjects who had, during the week, completed a study of "Charting on the Earth."

TABLE I
Analysis of Trial Test II

Items	55	Variance	137.3
Subjects	62	Standard deviation	11.7
Mean	26.0	Reliability[a]	0.922

[a] Reliability was established through use of the Kuder-Richardson reliability formula 20.

Construction of Materials

In the process of rewriting Chapter Four, there was need to control three areas with considerable rigor. First, it was necessary to state with some authority to what extent each factor was present in each treatment. Therefore, primary attention had to be focused on factor control. Second, the format of each treatment had to be substantially the same. Radical changes in illustrations, type, general attractiveness, or other aspects of format would inject a fourth uncontrolled variable into the study, making any statement of probable causality virtually impossible. Third, attention had to

TABLE II
Analysis of Factors Found in Each Treatment

Treatment	Variable factor	Questions	Activities	Incongruities
0	Original chapter	13	14	3
I	Emphasis on questions	30	14	3
II	Deemphasis of questions	0	14	3
III	Emphasis on activities	7	39	3
IV	Deemphasis of activities	8	0	3
V	Emphasis on incongruity	15	15	8
VI	Deemphasis of incongruity	2	14	0

be given to the readability level of the material. Any great difference would render comparison across treatments out of the question.

Six treatments were written. In each instance, one factor was either accentuated or minimized while the remaining two factors were held constant, i.e., found in approximately the same quantity as the original version. Thus, Treatment I lajd heavy stress upon questions by increasing the number but retained basically the same activities and incongruities as found in the original chapter.

Care was taken that all booklets, including the original, were in mimeograph form, that each had the same cover page, that all page layouts resembled as closely as possible that of the original, that all included the same illustrations, that all were typed with the same type, and that all contained the same number of pages. Treatment III represents an exception in two instances. Because of the additional activities, it was necessary to increase both the number of illustrations and the number of pages.

The Dale-Chall readability formula was applied to the seven treatments and the average grade level of each treatment was found to be 7–8. Therefore, no manipulation of the vocabulary or sentence length was necessary.

The seven treatments were then submitted to a panel of five judges to determine if there were actual detectable differences among the treatments. The treatments, arranged initially in a random order, were categorized correctly by all five judges. It seems reasonable to state that there was a difference in the manner in which the treatments were written and that this difference was great enough to permit knowledgeable educators to categorize them with a high degree of accuracy.

Teacher Selection and Treatment Implementation

An invitation was offered to sixth grade teachers in a South Florida county school system to participate in the study. Thirty-five teachers responded. These were arranged in alphabetical order and randomly assigned a treatment. Each of the seven treatments, the original and the six variations, was taught by five teachers. A total of 889 students in thirteen schools constituted the sample.

Prior to the teaching of the material, the investigator personally tested each of the thirty-five classes, ensuring that no test booklets were lost or previewed by the project teachers.

Following the pretest, enough astronomy booklets were delivered to each teacher for every subject. Booklets were not to leave the classroom nor were teachers to discuss the study until the post-test had been administered.

At the completion of the study, the investigator once again tested all subjects. Every attempt was made to make the situation closely resemble the pretest sessions. The post-test contained three additional questions which related directly to students attitudes. These were:

1. My feelings toward the astronomy we studied are:
   ( ) Liked very much; ( ) Liked Some; ( ) Undecided; ( ) Disliked Some; ( ) Disliked very much.
2. The chapter was:
   ( ) Very easy; ( ) Easy; ( ) Some easy, ( ) Some hard; ( ) Hard; ( ) Very hard.
3. I would like to study astronomy like this:
   ( ) Much more; ( ) A little more; ( ) Not sure; ( ) No more; ( ) Never again.

Hypotheses Tested

It was hypothesized for nine categories of subjects that no relationship existed between achievements test scores and treatment differences. These nine groups of subjects were:

1. Total sample.
2. Male subjects.
3. Female subjects.
4. Subjects with mental ages in the upper quartile of all subjects.
5. Subjects with mental ages in the lower quartile of all subjects.
6. Male subjects with mental ages in the upper quartile of all male subjects.
7. Male subjects with mental ages in the lower quartile of all male subjects.
8. Female subjects with mental ages in the upper quartile of all female subjects.
9. Female subjects with mental ages in the lower quartile of all female subjects.

Three additional hypotheses were tested concerning differences in the subjects' attitudes as related to their achievement scores for the seven treatments. It was hypothesized that a correlation of zero existed between the seven treatments, when ordered by their adjusted mean achievement test score for all subjects, and the order of the seven treatments when ordered by each of the following: (*1*) the extent to which the treatments were liked or disliked by all subjects; (*2*) the extent to which the treatments were perceived as being easy or difficult by all subjects; and (*3*) the extent to which the students desired to study more of similar material.

Statistical Treatment

Initially, hypotheses for subject groups 5 and 7 above were eliminated as untestable because of sampling problems. It was found that not all subjects within each of the two groups, *5* subjects with mental ages in the lower quartile of all subjects, and *7* male subjects with mental ages in the lower quartile of all male subjects, were drawn from a homogeneous population.

To determine if differences in achievement scores among treatments existed for the remaining seven categories of subjects, the five classes in each treatment were pooled and the data were analyzed through an analysis of covariance, holding the mental ages of subjects constant. Significant differences were found in achievement scores of subjects in six instances. Only the test of the hypothesis for subject group *8*, female subjects with mental ages in the upper quartile of all female subjects, produced no significant differences in achievement scores across the seven treatments. A summary of the findings is given in Table III.

Further analysis was made in an attempt to determine the influence of manipulation of individual factors upon achievement. An analysis of covariance was used in determining if there was a significant difference for each group of subjects in achievement test scores between (*1*) subjects who received materials which emphasized questions as opposed to subjects who received materials which deemphasized questions; (*2*) subjects who received materials which emphasized activity as opposed to subjects who received materials which deemphasized activity; (*3*) subjects who received materials which emphasized incongruity as opposed to subjects who received materials which deemphasized incongruity. With two exceptions, each subject group appeared to be sensitive only to the manipulation of one factor, and that factor varied among groups.

For example, females with mental ages in the lower quartile of all female subjects responded only to the manipulation of the factor "activity." Significant differences in achievement test scores were found only for this factor; printed materials containing thirty-nine activities resulted in significantly

TABLE III
Comparison of Order of Treatments as Determined by Mean Achievement Scores for the Six Hypotheses which were Rejected

Rank	All subjects	Males	Females	High M.A.	High M.A. males	Low M.A. females
1	III (activities)	III	III	II	II	III
2	II (no questions)	II	I	0	0	I
3	I (questions)	0	0	I	I	IV
4	0 (original)	I	II	III	IV	V
5	IV (no activity)	IV	IV	IV	III	II
6	V (incongruity)	V	VI	VI	VI	0
7	VI (no incongruity)	VI	V	V	V	VI
Level of significance	0.01	0.01	0.01	0.01	0.01	0.05

higher scores than did printed materials containing no activity. No significant differences in achievement were found between students studying materials with many questions and students studying materials with no questions or students studying materials with many incongruities and students studying materials with no incongruities.

It should be noted that the factor to which the students appeared to be highly "sensitive" also produced the highest mean achievement score. For instance, the females with low mental ages, referred to above, not only appeared to be most sensitive to the manipulation of the number of activities, but the highest mean achievement score recorded for the seven treatments was recorded for those subjects who received materials with an emphasis on activity.

Analysis of the total group of female subjects provided one exception. While there was a significant difference in their achievement test scores among the seven treatments, this difference was not accounted for through the manipulation of any single factor. As a second exception, subjects with high mental ages appeared to be sensitive to both the number of questions and the number of incongruities. However, while this latter group may have responded to differences in

TABLE IV
A Comparison of the Factors of Greatest Sensitivity and the Treatment Resulting in the Highest Achievement Score for Each Group of Subjects

Subject category	Factors of greatest sensitivity		Treatment resulting in highest achievement scores
	Factor	Direction resulting in higher achievement	
All subjects	Activity	Emphasis	III—Emphasis on activity
Males	Activity	Emphasis	III—Emphasis on activity
Females	None		III—Emphasis on activity
High mental aged subjects	Questions incongruity	Deemphasis Emphasis	II—Deemphasis of questions
High mental aged males	Questions	Deemphasis	II—Deemphasis of questions
Low mental aged females	Activity	Emphasis	III—Emphasis on activity

the number of incongruities, the response was neither as great as that for manipulation of questions nor did it result in a high performance on the post-test.

It should be pointed out that those subjects with high mental age scores deviated markedly from students in the mid and low ranges. This deviation was most marked in the factor category "questions" where the "high" category students received the highest mean achievement scores when studying from materials with no questions. In this treatment, all information and data was given directly to the student without questions to stimulate further thought or to call for class discussion. There were a minimum of activities, the majority of which required application of the newly presented information. However, manipulation of the number of activities made no significant difference in the mean achievement test scores of these students.

To investigate the relationship between a student's attitude and his achievement, the students were asked to mark one of five choices to indicate their like or dislike for the astronomy lessons, and the extent to which they would care to study more of similar material. A numerical value, one to five, was assigned to the responses. By tallying these values, it was possible to arrive at an average value for a treatment group. The seven treatments were than ranked as to the average attitude for subjects within each group. Since none of the subjects were familiar with the content, or had seen the material prior to the study, it was assumed that any attitudes held were developed as a result of the study.

To test the hypotheses of no correlation between the rank order of the treatments based upon the attitude questions and the rank order based upon the adjusted mean achievement scores for the total sample, Spearman's rank order coefficient was computed.

In each of the three instances it was found that a relationship did exist between test scores and attitudes, but this relationship could have occurred by chance. The data do not support the hypothesis that students who learn more content, as indicated by higher achievement scores, (*1*) like the material any better than lower scoring classmates, (*2*) perceive it as being easier, or (*3*) desire to study more similar material. However, it is interesting that the material with the greatest number of activities consistently ranked high, indicating the most favorable attitudes developed, while the materials with the greatest number of questions and the material with the least amount of incongruities consistently ranked low, indicating the least favorable attitudes developed.

TABLE V
Comparison of Order for the Seven Treatments on the Three Questions Concerning Attitudes and on the Adjusted Mean Achievement Scores

Rank	Adjusted mean achievement score	Subject like for the material	Perceived difficulty	Desire to study more of the same
1	III	III	0	III
2	II	0	III	0
3	I	IV	II	IV
4	0	II	V	II
5	IV	V	IV	V
6	V	I	VI	I
7	VI	VI	I	VI

Conclusions

The first and most obvious conclusion to be drawn from this study is that when the project teachers, unfamiliar with the content, taught astronomy through adhering closely to the materials provided, the manner in which those materials were written seemed to predetermine the amount of learning which took place. The data leave little in the way of doubt, as significant differences were noted between the mean achievement scores for the seven treatments in six instances. It appears that the factors investigated, the number of questions, activities, and incongruities, were basic in determining

the extent to which the students assimilated the content.

It also appears that not all factors were of equal importance for students within various categories. An increase or decrease in the presence of a given factor produced significant differences for one group of students but remained impotent in altering achievement scores of others. For example, manipulation of the number of activities resulted in significant differences in three of the six subject categories.

An analysis of the response of students to specific factors indicates that there was a high degree of selectivity operating within the student. The data further support the conclusion that for a given student, that factor to which he was most sensitive promoted the highest level of learning.

A student's sensitivity to a factor was either in terms of the presence or absence of that factor. In four instances, subjects within different categories responded best to the presence of many activities. In two instances students responded best to the absence of questions. This would suggest that materials produced for optimal learning must be founded upon both a recognition of that factor to which the student is most sensitive and the systematic control of its frequency.

Of the three factors investigated, activity produced the highest achievement scores for the majority of students. If material is to be written in only one form, it would seem that much activity would satisfy the greatest need. This, however, would not seem to meet the needs of students with mental ages in the upper quartile. The data suggest that students with high mental ages were capable of assimilating the content quickly and with comprehension. Thus, Treatment II, which contained no questions, provided the most successful mode of presentation.

Incongruity in printed material appears to be a factor of some consequence, but its exact role is not completely clear. The two treatments involved, Treatments V and VI, consistently produced low achievement scores. In only one instance were there significant differences between the treatments. This instance was due to the sensitivity of subjects with high mental ages. The factor appears to be quite nebulous, and it is entirely possible that incongruity was not adequately identified and subsequently manipulated for any clear lines of distinction to become evident. It is felt, however, that sufficient data were collected to attest to the importance of this factor and to demand further investigation.

The mental age of the student is critical in determining the extent to which a particular piece of material will be learned. Within the high and low mental age groups, Treatment II and III lay a maximum of five ranks apart, in inverse order. Use of a general description of this student population would only serve to construct a distorted image.

Of prime importance to this investigation were the attitudes which the students developed as a result of the seven treatments. These attitudes were analyzed for the entire group of subjects and not for subgroups. The data indicate that a specific piece of material was not only instrumental in determining the content which was learned but also developed a given set of attitudes.

In light of these data, a serious question must be raised with present practices of teachers and authors concerning the nature and use of texts and manuals. Generally, emphasis in the test is placed upon questions, specific and general. Activities are usually minimal in number, to be supplemented by those found in the teacher's manual. The data suggest that this procedure be reversed; that is, the activities and ideas for activities should be written into the material for the student, not into a manual of supplementary work. It is perhaps in the manual that suggestions for guiding the diverse interests of students and suggestions for a few highly productive discussions should be placed, aiding the teacher in drawing from the student ideas which will add unity to the lesson and provide the foundation from

which further explorations may develop. For the student with high mental age, the activities should be so structured that if only a minimum are needed for complete understanding, the student may move on, unrestricted by the individual needs of fellow students.

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